Comparative Test of Cylinder Lubricating Oils

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Comparative test of cylinder lubricating oils

COMPARATIVE TEST OF CYLINDER LUBRICATING OILS

A THESIS

PRESENTED BY

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B. C. HOOPER

TO THE

PRESIDENT AND FACULTY

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HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

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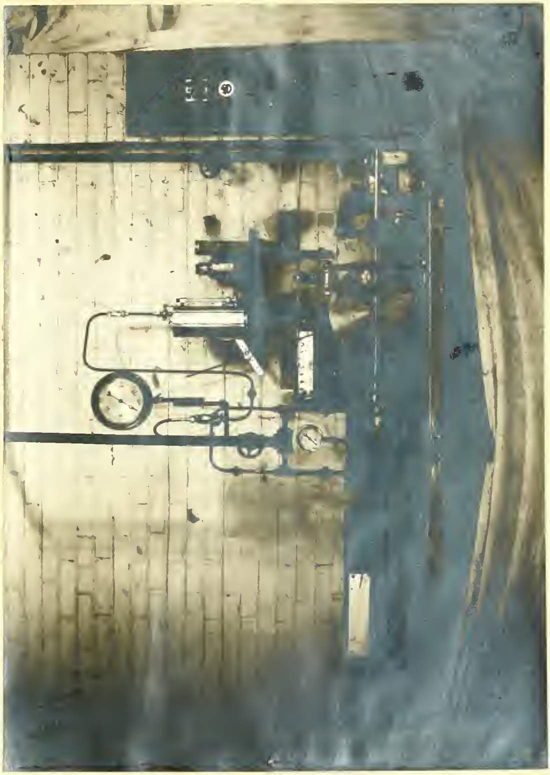

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THESIS.

COMPARATIVE TEST OF CYLINDER LUBRICATING OILS.

It was the intention, when beginning this thesis, to complete the work begun last year by Ralph Garfield Focht, the inventor of the oil testing machine. The drawings for this machine and a detailed description of the same, will be found enclosed in Mr. Focht's thesis of last year. It was proposed by us to make complete and comprehensive tests of various oils under all conditions of steam pressure, oil feed, and piston speed. Upon beginning these tests, it was readily ascertained that our aim would be to put the machine into such a condition that such tests would be feasible.

The machine, as described by Mr. Focht, was mounted on a bench in the south end of the engine room at Armour Institute. Power for operating the machine was obtained from a small motor placed under the bench and belted to a pulley on the shaft of the oil tester. The accompanying photograph shows the arrangement and complete appurtenances.

The piston, designed by Mr. Focht, consisting of an aluminum spider fitted with a cast-iron piston-ring, divided into four parts set upon helical springs, was not a success and our first task was to construct a new piston. The piston described above worked successfully without steam, but when placed under steam pressure, the piston became wedged against the cylinder walls and stalled the motor. An order was placed for a solid cast-iron ring one inch wide, to be shrunk on the piston. After waiting for some time and finding that no progress was being made on the work, we attempted it ourselves. Apattern was secured and a casting made. From this casting a solid ring, one inch wide, was turned up in the machine shop and shrunk on to the spider.

19500

This piston gave entire satisfaction when running without steam, but failed as did its predecessor when given steam.

Two grooves, one-quarter inch wide and three-sixteenths of an inch deep, were turned in the ring and two ordinary snap-rings made to fit the grooves. This piston worked all right for a short while, until the solid ring slipped off the spider. A brass plate was turned up of the same diameter as the ring and screwed onto one face of the piston, to hold these rings in place. This did not keep the solid ring from rotating on the spider, so it was pinned with small steel pins placed around the periphery.

The next failure of the piston was as before, in the cast-iron ring. The grooves had been cut almost through the ring, separating it into three parts, each about one-quarter of an inch wide. Each one of these parts cracked where the pin had been drivenin it and no longer held the piston rings parallel to each other. To overcome this diffivulty, the solid ring was discarded and a new casting made. The spider was turned down to secure a thicker ring, which was shrunk on as before. Grooves were cut in the ring, and the snap-rings and brass plate replaced. This piston seemed to work fairly well and we hoped that it would give results when worn in.

We next turned our attention to designing a mechanism for operating the revolution counter. A mechanical counter was mounted in back of the tester, against the wall where the device for operating the Lukenheimer lubricator could be used to give a reciprocating motion to run the counter also. A small steel pin was driven into the main rod on the lubricator and to this pin was attached a piece of stiff steel wire.

During the progress of wearing in the piston-rings, the belt and lubricator broke,both requiring some time to renew. Cards were taken after running the machine for two or three days without oil. These cards were comparatively smooth when the tester was running without steam,but as soon as steam was turned into the cylinder they assumed the appearance of a scenic railway. Various explanations were given for this and we set about to locate the trouble. The waves were so regular that harmonic vibration of some parts was suspected,but upon changing the speed of the machine this theory was exploded,for the waves assumed an entirely new position.

The most violent vibrations of the pencil motion , when turning the machine over slowly by hand,seemed to be at exactly the middle of the stroke. The piston covered the steam port at this point and allowed an unbalanced steam pressure to bear the piston down upon the bottom of the cylinder. To overcome this,two one-half inch holes were tapped into the counter bore on the top of the cylinder and connections made to a tee in the steam main. The one-inch port was plugged and a steam gauge piped through it to show the pressure in the cylinder.(See the accompanying print.)

This arrangement reduced the size of the waves in the cards,but did not eliminate them entirely. It was suspected that the piston was becoming wedged in the cylinder due to it having so much play around the main piston-rod. A brass sleeve was made to fit snugly in the piston and loose upon the main piston-rod. This prevented the piston from buckling and still created no friction between it and the main piston-rod.

The cards had a most peculiar appearance when the

piston-rings had become smooth,after these last changes. Either the upper line ,corresponding to the forward stroke,was smooth and the lower line was full of waves, or vice versa. This phenomenon put to rout all explanations as to the cause of the waves in the cards.

The inner piston-rod had become quite worn and a great amount of steam leaked out around the tail-rod. A new rod was constructed and the leak was partially overcome . As a last resort,it was decided to reduce the speed of the machine,already far below that of good engine practice. The pulley was removed from the motor and the shaft wound with tape. This proved to be a move in the right direction and showed conclusively that inertia of the piston was the cause of the waves in the cards. The waves were entirely eliminated from the cards when running the machine at eighty-seven revolutions per minute,except of course,the loops at the ends,due to enertia . These loops could never be eliminated with the present design of machine and piston.

Seven weeks had been spent by this time upon machine-shop work and pipe fitting,so it was decided to secure samples of oils and attempt to get results from the machine as it stood. The conditions under which all tests were made were as follows:-
87 revolutions per minute,6 drops of oil per minute, and steam pressure about 90 pounds. The lubricator and tester were cleaned carefully before each test with gasolene,and allowed to stand over night to evaporate all the gasolene. The machine was started with steam flowing through it and the feed adjusted until exactly six drops of oil were being fed into the cylinder per minute.

The tester was then run for two or three hours until the conditions had become constant, when cards were taken until the supply of oil had been exhausted. Each morning when the machine was started it was found that the cards were always of a greater area, showing that the oil had become gummed, or hardened in the cylinder over night. The following logs show the data obtained, together with the blue prints of sample cards.

CHART 1.

Data on Beaver Cylinder Oil. S.O.Co.
(Compounded mineral oil recommended for wet steam.)

May 22,1907.

Card.	Time.	R.P.M.	Steam Main.	Pressures Cylinder.	Area card sq. in.	Drops per minute.
1.	9:28	87	90	90	2:12	6
2.	9:41	87	90	90	2.12	6
3.	9:58	87	90	90	2.06	6
4.	10:15	87	90	90	2.15	6
5.	10:25	87	90	90	2.1[illegible]	6

CHART 2.

Data on pure tallow oil. D.D.& C.Co.

May 23,1907.

1.	11:40	87	90	90	2.10	6
2.	11:48	87	90	90	1.88	6
3.	11:54	87	90	90	1.89	6

CHART3.

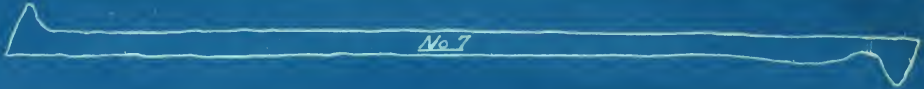
Data on Ft. Dearborn XX Cylinder Oil. D.D.& C.Co.
pure mineral oil.

1.	10:35	87	100	95	2.02	6
2.	10:40	87	100	95	2.05	6
3.	10:45	87	100	95	1:94	6
4.	10:50	87	100	95	2.00	6
5.	10:55	87	100	95	1.95	6
6.	11:00	87	100	95	2.02	6
7.	11:05	87	100	9 5	1.76	6
8.	11:10	87	100	95	2.02	6
9.	11:15	87	100	95	2.00	6
10.	11:25	87	100	95	1.80	6
11.	11:30	87	100	95	1.81	6

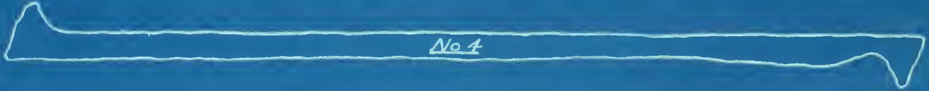
CHART 4.

Data on Capital Cylinder Oil. S.O.Co.
(Compounded mineral oil recommended for high pres.)

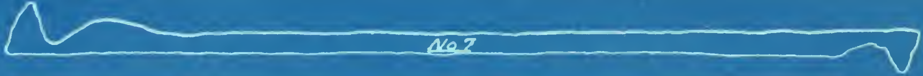
Card.	Time.	R.P.M.	Steam Pressures. Main.	Steam Pressures. Cylinder.	Area card. sq. in.	Drops per minute.
1.	10:08	87	95	95	1.90	6
2.	10:13	87	90	90	1.89	6
3.	10:18	87	85	85	1.76	6
4.	10.26	87	85	85	1.80	6
5.	10:35	87	85	85	1.63	6
6.	10:50	87	85	85	1.71	6
7.	11:00	87	85	85	1.62	6



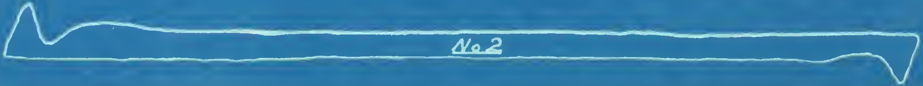
FT. DEARBORN. XX.

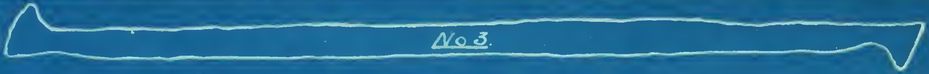


SAMPLECARDS.

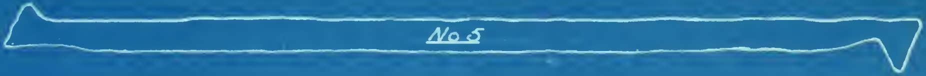


CAPITAL OIL.

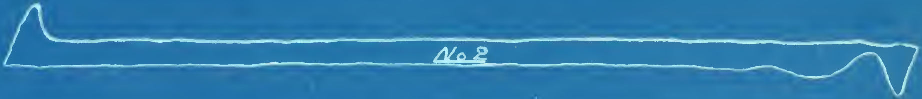




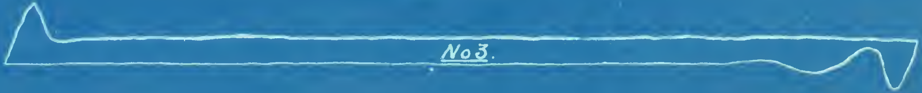
BEAVER OIL.

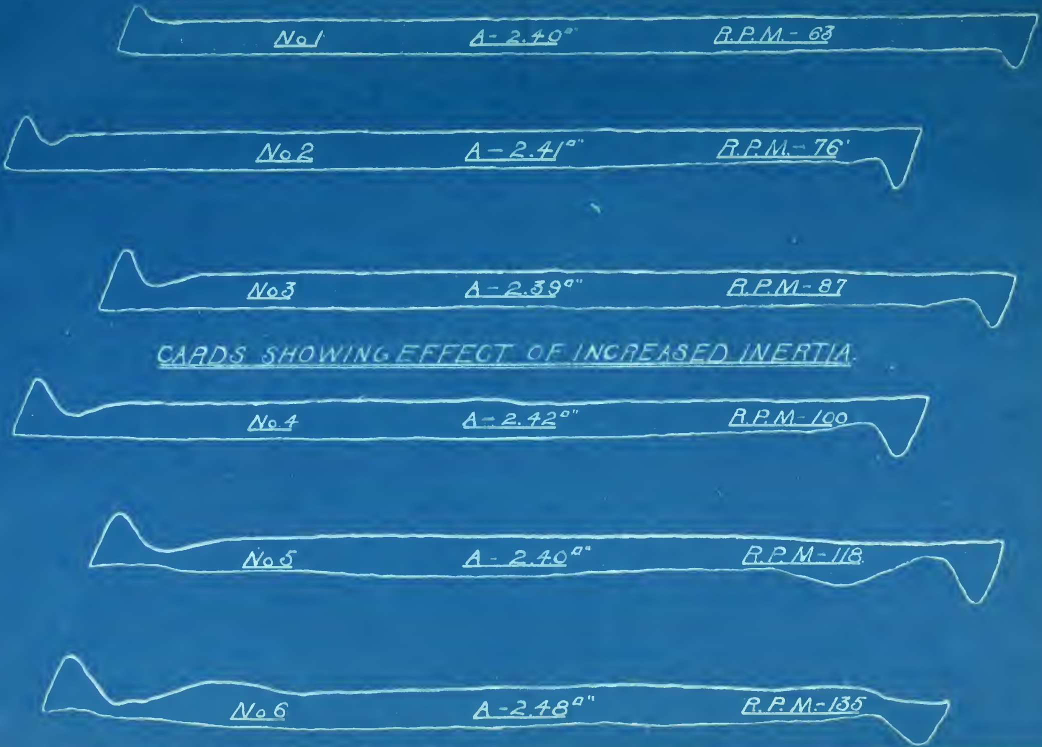


SAMPLE CARDS.



PURE TALLOW.





CARDS SHOWING EFFECT OF INCREASED INERTIA.

It will be seen from the set of six cards, showing the effect of increasing the speed, that the inertia forces distort the cards and give fictitious results. These cards were taken with steam in the cylinder, but no lubricant. The increased speed shows little effect upon the area of the cards until a speed of 135 revolutions per minute is reached. At sixty-three revolutions per minute, the lines are almost straight and the curves due to inertia forces are a minimun. With increased speed, the cards become more wavy and less reliable.

There is an error in integrating these cards as a work diagram, because the area s under the loops at each end of the card are due to inertia forces, and not to friction. The ideal card would be a rectangle. If the cards were made up of perfectly straight parallel lines, the width of the card could be taken as proportional to the work done. The spring used was an 80 pound spring from a Thompson indicator, having a scale of 160 pounds to the inch. The ratio of the arms of the pencil motion is 6:1, so that one inch on the diagram represents a force of 160/6 , or 26.67 pounds. Referring to card #1 of the variable speed series, the width of the card is 5/16 of an inch. This represents a force of 8.33 pounds, or divided equally on each stroke, a total force of 4.16 pounds, due to friction.

A glance at the charts containing the data will show that there is no consistency in the results. The friction is so small compared to the other forces acting, that the machine is not delicate enough to show indisputable differences in the diagrams obtained from different oils. The pencil motion is so designed that there is bound to be a certain amount of lost motion, due to

wear,which introduces an error. The piston,although constructed of aluminum,is far too heavy for the spring,which must be delicate,to give large and comparable diagrams. The piston tends to lag behind,when the engine i s on the forward stroke,running over, This places the spring in dompression.The main rod comes to a stop and reverses,when the crank reaches the outer dead center. The piston tends to keep on in the direction in which it is moving. This releives the tension in the sprin and puts it in compression for the return stroke. The spring does not recover immediately,when the machine is running fast ,and tends to keep up this vibration. The result is a series of waves in the line representing that stroke. In this manner the inertia forces act on the spring and give fictitious results. If the tests are made at the same speed, the increase in area due to inertia waves should be the same in each case,and the results should be comparable,as far as indicatin g maximum or minimum friction.

The mechanism for operating the pencil motion should be so sensitive and free that when the spring is placed in tension or compression,by some external force,it would immediately assume its normal length,when that external force is removed. This mechanism will not do that,and is therefore not sensitive enough. There should be some way of taking up the wear in the block which travels in the yoke. Any lost motion in the yoke seriously affects the operation of the pencil motion. The piston is not attached rigidly enough to the inner piston-rod and tends to buckle and vibrate.

We believe that if an oil were fed into the machine , under constant conditions for eight,or ten hours,that results could be obtained,which would be roughly comparable,but by no means accurate. The cards would not be an accurate measurement of the work performed in the cylinder,as the machine is not delicate enough. Our conclusions are,that the machine used in these tests is not accurate,or sensitive enough to discriminate reliably between oils;and,it is not adapted to the measurement of the lost work of friction,for which it was designed. We would recommend in the future design of such a machine,that some method be used for measuring the intensity of pressure between the piston and the cylinder walls,and that a more sensitive,and delicate pencil motion be used.

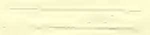
Comparative Test of Cylinder Lubricating Oils.

Cards taken on Ft. Dearborn XX Oil.

5-25-07.

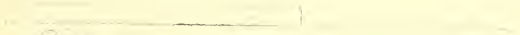
B. Hoffmann, Jr.

B. C. Hooper



R.P.M. 87 St.P.–100 Ft. D XX
Fd. 6/min T – 10:25

2.02



R.P.M. – 87 T – 10:40
St P – 100#
Fd – 6/min Ft D XX

1.01

2.05

R.P.M. – 87 T – 10:45
Fd – 6/min
St. P – 100# Ft. D XX

1.00

R.P.M. - 87 T- 10:50
St. P - 100# Ft. D - XX
Fd - 6/min

2.00

R.P.M. - 87
St. P. - 100# T- 10:55
Fd, 6/min Ft. D XX

1.95

R.P.M. - 87 T- 11:00
St. P. 100# Ft. D XX
Fd - 6/min

98

2.0 ✓

R.P.M. - 87 T- 11:05
Fd - 6 min
St. P - 100 Ft D XX

1.76

101

R.P.M. - 87 T- 11:10
St. P - 100# Ft D XX
Fd - 6/min

✓

R.P.M. - 87 T- 11:15
St. P - 100# Ft. D. XX
Fd - 6/min

R.P.M. - 87
St. P - 100# T- 11.25
Fd 6/min Ft. D - XX

1.80

R.P.M. - 87 Fd - 6/min
St. P - 100# T- 11:30 Ft. D - XX

.87

18

Comparative Test of Cylinder Lubricating Oils.

Cards taken on Capital Oil.

5-27-07.

B. Hoffmann, Jr.

B. C. Hooper

1.00

5/27/07 Capital Oil

6 drops - 87 R.P.M 2.0

9^{45} am

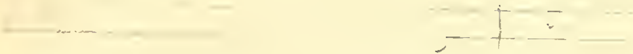
95# - 95#

1.01

Do not use this

10^{06} .84 | 97

10^{16}



95

.95

5/27/07 Cap. Oil

6 drops 87 RPM

10^{08} am 95# - 95#

1.9

.9

5/27/07 Cap Oil - 6 drops

10^{13} am 87 RPM 90-90

1.89

5/27/07 - 10¹⁸ am Cap. [illegible] - 6 - 87
85 - 85

.90

83

.76

.90

90

5/27/07 - Capbel - 6 - 87

180

10 [illegible] am
85 - 85

5/27/07 - capbel - 6 - 87

10³⁵ am 85 - 85

.83

.9

.82

capbel - 6 - 87

5/27/07

10³⁰ am 85 - 85

.81

5/27/07 Capbel - 6 - 87

.81

11⁰⁰ am 85 - 85

.62

Comparative Test of Cylinder Lubricating Oils.

Cards taken on Beaver Oil.

5-22-07.

B. Hoffmann, Jr. B. C. Hooper

9^{11} Am Beaver Oil - 6 drops per min

5/22/07 91# gauge 90# cyl 87 R.P.M.

Do not use

5/22/07 6 drops per min - 9^{28} Am.

90# - 90# 2.18

87 R.P.M

22/07

9^{41} Am Beaver Oil - S.O. Co. - 6 drops

90# - 90# 1.07 1.05

87 R.P.M. 2.18

9^{58} Am - 5/22/07

Beaver Oil - S.O. Co. - 6 drops 1.05

87 R.P.M. 1.01

93# 90# cyl. 2.26

10^{05} Am 5/22/07

1.10

Beaver Oil - St. Oil Co -

87 R.P.M. 90# 90# 2.17

5/22/07 10^{15} Am.

1.00

Beaver Oil ~~Co~~ - S.O. Co. - 7 drops 1.15 2.15

90# - 90# 87 R.P.M.

Comparative Test of Cylinder Lubricating Oils.

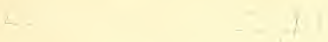
Cards taken on tallow oil.

5-23-07.

E. Hoffmann, Jr.

B.C. Hooper

11⁵⁰ am 5/23/07

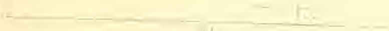


Tallow - 6 d

90# - 90#

87 R.P.M.

1.84



11⁴⁵ am Pure Tallow.

5/23/07 87 R.P.M. 6 drops 90# - 90#

1.81

11⁴⁰ am 5/23/07 Tallow oil - 6 drops 1.00

" 87 R.P.M.

90# - 90#

2.10

Do not use

5/23/07 8⁵⁰ am Tallow Oil

86 R.P.M.

Do not use

5/23/07 on starting Tallow Oil

9⁴⁵ am. R.P.M. 86

Do not use

63 R.P.M.

76 R P M

87 R P M

180 R P M

1.2

118 R P M

135 R P M